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Temporal Trends in Healthcare Costs and Outcome Following ICU Admission After Traumatic Brain Injury

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Objective: To assess temporal trends in 1-year healthcare costs and outcome of intensive care for traumatic brain injury in Finland.

Design: Retrospective observational cohort study.

Setting: Multicenter study including four tertiary ICUs.

Patients: Three thousand fifty-one adult patients (≥ 18 yr) with significant traumatic brain injury treated in a tertiary ICU during 2003–2013.

Intervention: None.

Measurements and Main Results: Total 1-year healthcare costs included the index hospitalization costs, rehabilitation unit costs, and social security reimbursements. All costs are reported as 2013 U.S. dollars ($). Outcomes were 1-year mortality and permanent disability. Multivariate regression models, adjusting for case-mix, were used to assess temporal trends in costs and outcome in predefined Glasgow Coma Scale (3–8, 9–12, and 13–15) and age (18–40, 41–64, and ≥ 65 yr) subgroups. Overall 1-year survival was 76% (n = 2,304), and of 1-year survivors, 37% (n = 850) were permanently disabled. Mean unadjusted 1-year healthcare cost was $39,809 (95% CI, $38,144–$41,473) per patient. Adjusted healthcare costs decreased only in the Glasgow Coma Scale 13–15 and 65 years and older subgroups, due to lower rehabilitation costs. Adjusted 1-year mortality did not change in any subgroup ($p < 0.05$ for all subgroups). Adjusted risk of permanent disability decreased significantly in all subgroups ($p < 0.05$).

Conclusion: During the last decade, healthcare costs of ICU-admitted traumatic brain injury patients have remained largely the same in Finland. No change in mortality was noted, but the risk for permanent disability decreased significantly. Thus, our results suggest that cost-effectiveness of traumatic brain injury care has improved during the past decade in Finland. (*Crit Care Med* 2018; 46:e302–e309)

Key Words: cost-effectiveness; intensive care unit; outcome; traumatic brain injury; treatment cost; treatment intensity

Traumatic brain injury (TBI) is a globally growing problem (1, 2). In Europe and the United States, the increasing occurence of elderly people falling is changing the epidemiology of TBI, and the rising age of patients treated in ICUs has drastically increased the demand for ICU beds (3–6).

Intensive care treatment is expensive, comprising 4% of the national healthcare expenditures and 0.5% of the national gross domestic product in the United States alone (5). Yet, extensive cost-analysis data for ICU-treated TBI patients is virtually nonexistent. In Finland, all specialized tertiary care of TBI patients (including neurosurgical and neurointensive care) has for several decades been centralized to five publically funded university hospitals (7). Further, the same Social Insurance Institute (SII) covers all Finnish citizens, allowing for a unique opportunity to comprehensively assess the economic burden of TBI.

Our primary aim was to evaluate temporal trends in 1-year healthcare costs and outcome of intensive care for patients with TBI from 2003 to 2013 treated in tertiary Finnish ICUs. As secondary aims, we aimed to assess temporal changes in treatment intensity and to assess cost-effectiveness in some clinically relevant predefined subgroups. We hypothesized that healthcare costs and treatment intensity have increased without any change in patient outcome.

METHODS

The ethics committee of the Operative Division of Helsinki University Hospital, the Finnish National Institute for Health and Welfare, Statistics Finland, the Social Insurance Institution, the Office of the Data Protection Ombudsman, and all the participating university hospitals' ethics committees approved this study.

Study Design and Population

We performed a multicenter retrospective observational study using data that were prospectively collected from the Finnish Intensive Care Consortium (FICC) database. The FICC database is a nationwide prospectively data collecting database including all ICU-treated patients from the majority of all ICUs in Finland (7–9). In Finland, all specialized tertiary intensive care of TBI patients is centralized to five tertiary ICUs. Four of these ICUs participate in the FICC. From these four tertiary ICUs, we included all adult TBI patients (age ≥ 18 yr) admitted from January 1, 2003 to December 31, 2013 (readmissions excluded). **Figure 1** shows a flow chart of included and excluded patients.

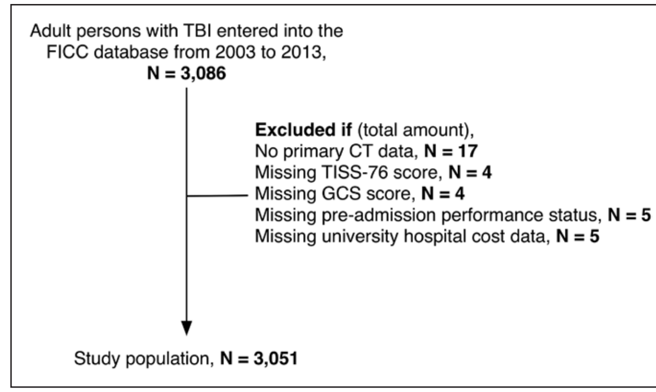

Figure 1. Flow chart showing the inclusion and exclusion process. FICC = Finnish Intensive Care Consortium, GCS = Glasgow Coma Scale, TBI = traumatic brain injury, TISS-76 = Therapeutic Intervention Scoring System 76.

Outcome Variables

We used 1-year mortality as the primary outcome of interest. Data on the date of death were obtained through the Finnish population register (available for all patients) and the archive of death certificates. As a secondary outcome of interest, we used a surrogate variable of permanent disability, defined as if the patient was granted a permanent disability allowance or disability pension by the SII. The SII is a Finnish government agency funded by tax money, insurance payments, and municipalities that provide all social security payments in Finland. The SII mandates one to be unable to independently carry out daily activities (e.g., self-hygiene, basic housekeeping, take care of things outside the home) or to be unable to return to work, for a minimum of 1 consecutive year (following the injury), in order to grant a permanent disability allowance or disability pension. Thus, we defined all patients who were granted permanent disability allowance or permanent disability pension from the SII (by September 30, 2016) as being permanently disabled. The SII's criteria for granting permanent disability allowances did not change during the study period. We also investigated hospital mortality, which we retrieved directly from the FICC database. The Therapeutic Intervention Scoring System (TISS) 76 was used as a marker of ICU treatment intensity. The TISS-76 includes a set of 76 selected therapies used in intensive care and was developed to quantify the intensity of care required by critically ill patients (10, 11). The TISS-76 variables are entered to the FICC database, as part of standard clinical practice.

Cost Data

We obtained all direct costs for the first year following TBI, including index hospitalization costs, rehabilitation hospital costs, and social security costs. We obtained direct cost data regarding the patients' index hospitalization directly from the university hospitals' invoicing departments (referred to as "university hospital costs"). These include costs for the whole treatment period, including all the incurred expenses (e.g., personnel costs, surgery, ICU stay, laboratory costs, radiologic costs, and ward stay). We found the rehabilitation unit costs (referred to as "rehabilitation unit costs") by calculating the length of stay in the rehabilitation unit multiplied by the average price of 1 ward day in the designated level of care unit according to the report from the Finnish National Institute for Health and Welfare (12). We obtained social security costs, including disability allowances, sickness allowances, private physician and physiotherapist expenses, prescription drug expenses, and medical travel costs directly from the SII (referred to as "social security costs"). We included all reimbursements granted for a period of up to 1 year after the TBI. The total 1-year healthcare cost was calculated as the sum of the university hospital costs, rehabilitation unit costs, and social security costs.

To evaluate cost-effectiveness, we calculated the effective cost per survivor (ECPS) and effective cost per independent survivor (ECPIS), which is defined as the cost for all patients divided by the number of (independent) survivors (13). The ECPS and ECPIS were calculated for all patients and for the predefined subgroups (see "subgroup analyses").

We adjusted all costs according to the consumer price index (CPI) in Finland to 2013 Euros (14). The CPI-adjusted costs were calculated as follows:

$$CPI\ adjusted\ cost = Cost * \frac{CPI\ in\ 2013}{Admission\ year\ CPI}$$

All CPI-adjusted costs were then converted to 2013 U.S. dollars (USD) using the Purchasing Power Parities (PPP) (2013 PPP [Finnish national currency unit in 2013/USD in 2013] = 0.905) (15).

Statistical Methods

We used SPSS Statistics 24.0 for mac OS (IBM Corp, Armonk, NY) and Stata Statistical Software for mac OS (StataCorp LP, College Station, TX) for the statistical analyses.

To adjust for case-mix over the years, we created a severity of illness model that included age, gender, Glasgow Coma Scale (GCS) score, chronic comorbidity, World Health Organization/Eastern Cooperative Oncology Group classification, Marshall CT classification, and Simplified Acute Physiology Score (SAPS) II total score (excluding age, GCS score, and chronic comorbidity). The GCS score is defined as the worst measured GCS score during the first ICU day in accordance to the Acute Physiology and Chronic Health Evaluation II definition (16). The last reliable GCS was used for intubated and/or sedated patients (7). The area under receiver operator curve (AUC) was 0.86 (95% CI, 0.85–0.87) for 1-year mortality prediction, indicating excellent discriminative power, and 0.67 (95% CI, 0.66–0.69) for permanent disability prediction, indicating satisfactory discriminative power. Temporal trends in costs and treatment intensity were evaluated using linear regression and temporal trends in 1-year mortality and permanent disability were evaluated using logistic regression, all models adjusting for the severity of illness model and using year of admission as a continuous variable (8).

Adjusted rates of 1-year mortality and permanent disability were reported as odds ratios, risk-adjusted mortality (RAMR), and risk-adjusted disability (RADR) rates. The RAMR and RADR were calculated as the ratio between the observed and predicted outcome multiplied by the overall outcome rate in the specific patient group. The RAMR and RADR represented the estimated outcome rate if the patient case-mix was constant for each year (8).

The study was done in accordance with the Strengthening the Reporting of Observational studies in Epidemiology guidelines (**Supplemental Methods 1**, Supplemental Digital Content 1, http://links.lww.com/CCM/D196).

Subgroup Analyses

We divided the patients into predefined clinically relevant subgroups according to GCS score and age. The GCS subgroups were 3–8 (severe TBI), 9–12 (moderate TBI), and 13–15 (mild TBI). The age subgroups were 18–40 years (young), 41–64 years (middle-aged), and 65 years and older (old). The ECPS and ECPIS were calculated separately in all six subgroups.

RESULTS

The study population consisted of 3,051 patients (Fig. 1). The baseline characteristics are presented in **Table 1**. Forty-seven percentage were classified as severe TBI (GCS, 3–8), 20% as moderate TBI (GCS, 9–12), and 33% as mild TBI (GCS, 13–15). Twenty-four percentage were classified as young, 47% as middle-aged, and 29% as old. Patients with mild TBI were somewhat younger than patients with moderate or severe TBI (**Supplemental Table 1**, Supplemental Digital Content 2, http://links.lww.com/CCM/D197).

The number of ICU-admitted TBI patients increased from 151 in 2003 to 326 in 2013. In comparison to all ICU admissions during 2003–2013, the relative proportion of TBI admissions increased from approximately 1% per year to approximately 2% per year (**Supplemental Table 2**, Supplemental Digital Content 3, http://links.lww.com/CCM/D198). The major change was a higher proportion of less severely injured TBIs (higher GCS, lower SAPS II). There were no changes in restriction of withdrawal of intensive care during the study period (range, 6–11%; $p = 461$).

Unadjusted hospital mortality was 12% and unadjusted 1-year mortality was 24% (for outcomes in the subgroups, see **Supplemental Table 3**, Supplemental Digital Content 4, http://links.lww.com/CCM/D199). Permanent disability in 1-year survivors was 37%.

Temporal Trends in Healthcare Costs

Mean 1-year healthcare cost per patient was $39,809 (95% CI, $38,144–$41,473). University hospital costs constituted 44%, rehabilitation unit costs were 42%, and social security costs represented 14% of the 1-year healthcare costs (**Supplemental Fig. 1**, Supplemental Digital Content 5, http://links.lww.com/CCM/D200; l**egend**, Supplemental Digital Content 8, http://links.lww.com/CCM/D203).

Including all patients, case-mix adjusted 1-year healthcare costs decreased by a mean of $740 (95% CI, $1,294–$187) per year; university hospital costs increased by a mean of $290 (95% CI, $28–$550) per year; rehabilitation unit costs decreased by a mean of $1,107 (95% CI, $1,492–$723) per year; social security costs did not significantly change during the study period.

TABLE 1. Patient Baseline Characteristics

Variables	All Patients (n = 3,051)
Age (yr), median (IQR)	56 (41–67)
18–40, n (%)	741 (24)
41–64, n (%)	1,429 (47)
≥ 65, n (%)	881 (29)
Glasgow Coma Scale score, median (IQR)	9 (5–14)
3–8, n (%)	1,441 (47)
9–12, n (%)	594 (20)
13–15, n (%)	1,016 (33)
Females, n (%)	698 (23)
Preadmission performance status[a], n (%)	
Fit for work or equal	1,865 (61)
Unfit for work, but independent in self-care	954 (31)
Partially dependent in self-care	178 (6)
Totally dependent in self-care	54 (2)
Significant chronic comorbidity[b], n (%)	261 (9)
Operative admission, n (%)	1,108 (36)
Mechanical ventilation, n (%)	2,039 (67)
Intracranial pressure monitoring, n (%)	722 (24)
LOS university neurosurgical ICU (d), median (IQR)	2 (1–4)
LOS university hospital (d), median (IQR)	6 (3–11)
Acute Physiology and Chronic Health Evaluation II score, median (IQR)	19 (13–24)
Simplified Acute Physiology Score II, median (IQR)	35 (24–50)
Sequential Organ Failure Assessment score[c], median (IQR)	6 (3–8)
Marshall CT classification, n (%)	
I	316 (10)
II	982 (32)
III	287 (9)
IV	45 (2)
Evacuated mass lesion/nonevacuated mass lesion	1,421 (47)

IQR = interquartile range, LOS = length of stay.

[a]A modified World Health Organization/Eastern Cooperative Oncology Group classification system implemented by the Finnish Intensive Care Consortium.

[b]Any chronic comorbidity according to Acute Physiology and Chronic Health Evaluation II or Simplified Acute Physiology Score II.

[c]Missing for seven patients.

In subgroup analysis, healthcare costs decreased only in patients with mild TBI and in old TBI patients (**Table 2**). In the mild TBI group, the cost reduction was due to lower rehabilitation costs (mean annual reduction, $890). In the old age group, the cost reduction was due to lower rehabilitation costs (mean annual reduction, $2,154), although university hospital costs increased slightly (mean annual increase, $658). In patients with severe and moderate TBI, university hospital costs increased (mean annual increase, $1,056 and $576, respectively), rehabilitation costs decreased (mean annual decrease, $1,046 and $400, respectively), and social security costs increased (mean annual increase, $210 and $316, respectively). University hospital costs did not significantly change in the young- and middle-aged subgroups.

The sum of total healthcare costs for all 3,051 patients was $121.5 million (mean, $11.0 million/yr) (**Supplemental Fig. 2**, Supplemental Digital Content 6, http://links.lww.com/CCM/D201; legend, Supplemental Digital Content 8, http://links.lww.com/CCM/D203). In 2003, the sum of all costs was $7.1 million, and in 2013, the sum increased to $10.8 million.

Temporal Trends in Outcome

Overall, 1-year RAMR was 25% (95% CI, 18–28%) and did not significantly change during the study period (p = 0.14) (**Fig. 2**). Nor did the 1-year RAMR change in any of the predefined study groups (**Table 3**).

RADR decreased significantly during the study period from 37% (95% CI, 29–45%) in 2003 to 19% (95% CI, 16–25%) in 2013 (Fig. 2). Case-mix adjusted risk for permanent disability decreased in all subgroups (Table 3).

Temporal Trends in Treatment Intensity

Case-mix adjusted treatment intensity decreased significantly during the study period by a mean of 0.21 of the mean daily TISS-76 (p < 0.001). Treatment intensity decreased significantly only in the young, middle-aged, and mild TBI subgroups (Table 2). Treatment intensity did not significantly increase in any subgroup.

Cost-Effectiveness

The overall ECPS was $52,716, and the overall ECPIS was $83,533. The ECPS and ECPIS were systematically higher in older patients and in patients with lower GCS scores (**Supplemental Fig. 3**, Supplemental Digital Content 7, http://links.lww.com/CCM/D202; legend, Supplemental Digital Content 8, http://links.lww.com/CCM/D203). The ECPIS was approximately two times lower among young patients compared with old patients irrespective of GCS. The difference in ECPIS was almost as pronounced between young and old-aged patients as it was between young and middle-aged patients, except for in mild TBIs, where middle-aged patients had a notably better ECPS and ECPIS than old patients.

DISCUSSION

Key Findings

In this comprehensive cost-effectiveness study, 1-year healthcare costs following ICU admission after significant TBI has remained largely the same in Finland from 2003 to 2013. A

TABLE 2. Temporal Change in Case-Mix Adjusted Costs

	Mean Annual Change in Total 1-yr Cost		
	Mean Annual Change	95% CI	*p*
Total healthcare costs	−740	−1,294 to −187	0.009
GCS 3–8			
Total healthcare costs	220	−690 to 1,129	0.67
University hospital costs	1,056	619–1,492	< 0.001
Rehabilitation costs	−1,046	−1,681 to −411	0.001
Social security costs	210	74–346	0.002
GCS 9–12			
Total healthcare costs	491	−502 to 1,485	0.33
University hospital costs	576	60–1,091	0.029
Rehabilitation costs	−400	−1,069 to 268	0.24
Social security costs	316	110–522	0.003
GCS 13–15			
Total healthcare costs	−1,119	−1,901 to −336	0.005
University hospital costs	−137	−455 to 182	0.40
Rehabilitation costs	−890	−1,484 to −295	0.003
Social security costs	−92	−245 to 62	0.24
Age 18–40 yr			
Total healthcare costs	−43	−1,310 to 1,224	0.95
University hospital costs	453	−233 to 1,138	0.20
Rehabilitation costs	−526	−1,212 to 159	0.13
Social security costs	30	−158 to 219	0.75
Age 41–64 yr			
Total healthcare costs	−471	−1,238 to 297	0.23
University hospital costs	205	−154 to 565	0.26
Rehabilitation costs	−873	−1,392 to −355	0.001
Social security costs	197	43–351	0.012
Age ≥ 65 yr			
Total healthcare costs	−1,401	−2,405 to −414	0.006
University hospital costs	658	308–1,008	< 0.001
Rehabilitation costs	−2,154	−3,028 to −1,281	< 0.001
Social security costs	86	2–171	0.045

GCS = Glasgow Coma Scale.

Annual changes in costs and treatment intensity were assessed using linear regression adjusting for a severity of illness model including age, gender, GCS score, significant chronic comorbidity, World Health Organization/Eastern Cooperative Oncology Group classification, Marshall CT classification, Simplified Acute Physiology Score II total score without the age, GCS score, and chronic comorbidity components. Total healthcare costs include university hospital costs, rehabilitation unit costs, and social security costs. Costs are expressed as 2013 U.S. dollars ($).

reduction in healthcare costs was noted in mild and in older TBI patients, due to lower rehabilitation costs. No reduction in healthcare costs was noted in patients with moderate and severe TBI, although university hospital costs increased in these groups. There was no significant change in adjusted 1-year mortality in any of the subgroups. Yet, adjusted risk for permanent disability decreased in all subgroups, suggesting improved cost-effectiveness of TBI care.

Although university hospital costs increased in some subgroups, it did not affect total healthcare costs, as rehabilitation

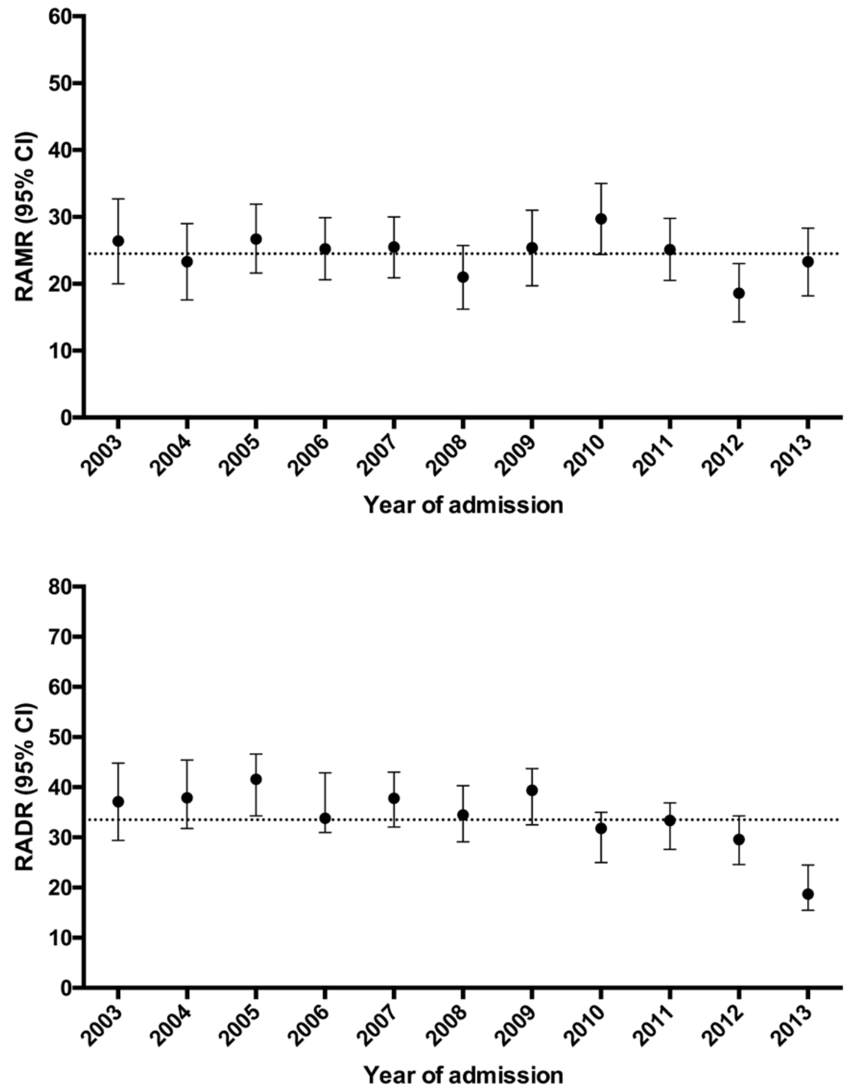

Figure 2. Temporal trend in 1-year risk-adjusted mortality rate (RAMR) and risk-adjusted permanent disability rate (RADR). The RAMR represents the estimated 1-year mortality rate if the patient case-mix was identical for each year. RADR represents the estimated disability rate if the patient case-mix was identical for each year. Overall, the 1-year RAMR was 25% (95% CI, 18–28%) and did not significantly change during the study period ($p = 0.14$). Overall, RADR decreased from 37% in 2003 to 19% in 2013. An increasing admission year was significantly associated with a decreased risk for permanent disability (odds ratio, 0.92; 95% CI, 0.90–0.95).

costs decreased accordingly. Rehabilitation costs was calculated as length of stay in the rehabilitation unit times a constant price given by the Finnish National Institute for Health and Welfare (12). Thus, the only possibility of lower rehabilitation costs is shorter rehabilitation times or a transition to lower level of care rehabilitation units, that are associated with lower costs. The reduction in rehabilitation costs did, however, not reflect in worse outcomes as risk of mortality and permanent disability did not increase.

Interestingly, changes in treatment intensity did not correlate with university hospital costs. University hospital costs remained the same in the mild TBI-, young-, and old-subgroups, despite decreased treatment intensity. Conversely, treatment intensity did not change in the severe TBI-, moderate TBI-, and old-subgroups, although these subgroups' university hospital costs increased. Treatment intensity was measured using the TISS-76 (11). The TISS-76 might, however, be considered a suboptimal instrument to evaluate treatment intensity in TBI patients, as it does not include neurointensive-specific treatment interventions. Using, for example, the therapy intensity level that was specifically designed to measure treatment intensity in TBI patients might have revealed different results (17). Although we cannot verify this, modern monitoring (e.g., brain tissue oxygen, brain tissue lactate and pyruvate, temperature, and electroencephalography) and imaging (e.g., MRI and CT perfusion imaging) have probably increased, leading to increased costs. The benefits on patient outcome and treatment cost-effectiveness of implementing such novel modalities should be addressed in future studies.

In Finland, the proportion of patients admitted to tertiary ICUs due to TBI, in comparison with other admission causes, have doubled during the last decade. This appears largely caused by an increasing number of mild TBIs being admitted to ICUs, leading to a less severely injured TBI population in the later years. In addition, more elderly patients are treated in tertiary ICUs. As a result, the total sum of healthcare costs resulting from tertiary ICU care of TBI have increased significantly. The sum of 1-year healthcare cost for all patients was approximately $122 millions. Of this, $54 millions, or 45% of the overall sum, went to independent survivors. Cost-effectiveness was notably better among young TBI patients irrespective of TBI severity. For example, in young patients with severe TBI, this ratio was 53%, but it was only 31% in old severe TBI patients. Thus, most of the resources used do not result in a favorable patient outcome. Given an aging population, this will pose great challenges to the neurosurgical and neurocritical care communities in the future.

TABLE 3. Temporal Change in Case-Mix Adjusted 1-Year Mortality, Permanent Disability, and Treatment Intensity

Patient Groups	OR	95% CI	*p*
Mean Annual Change in Risk of 1-Yr Mortality			
Overall	0.98	0.94–1.01	0.14
GCS subgroups			
3–8	0.98	0.94–1.03	0.42
9–12	0.95	0.87–1.04	0.27
13–15	0.94	0.85–1.03	0.15
Age subgroups (yr)			
18–40	0.91	0.82–1.00	0.06
41–64	0.95	0.90–1.00	0.06
≥ 65	1.00	0.95–1.06	0.88
Mean Annual Change in Risk of Permanent Disability			
Overall	0.92	0.90–0.95	< 0.001
GCS subgroups			
3–8	0.96	0.92–0.99	0.026
9–12	0.92	0.87–0.98	0.010
13–15	0.86	0.82–0.91	< 0.001
Age subgroups (yr)			
18–40	0.85	0.79–0.92	< 0.001
41–64	0.93	0.89–0.96	< 0.001
≥ 65	0.95	0.90–0.99	0.037
Patient Groups	**Mean Annual Change**	**95% CI**	***p***
Mean Annual Change in Treatment Intensity (Therapeutic Intervention Scoring System 76) Per Patient			
Overall	−0.21	−0.30 to −0.12	< 0.001
GCS subgroups			
3–8	0.12	−0.01 to 0.24	0.07
9–12	0.05	−0.15 to 0.24	0.63
13–15	−0.38	−0.52 to −0.25	< 0.001
Age subgroups (yr)			
18–40	−0.20	−0.39 to 0.00	0.045
41–64	−0.21	−0.33 to −0.09	0.001
≥ 65	0.00	−0.15 to 0.15	0.96

GCS = Glasgow Coma Scale, OR = odds ratio.

Independent effect of admission year on 1-year mortality and permanent disability rates using logistic regression adjusting for a severity of illness model including age, gender, GCS score, significant chronic comorbidity, World Health Organization/Eastern Cooperative Oncology Group classification, Marshall CT classification, Simplified Acute Physiology Score II total score without the age, GCS score, and chronic comorbidity components. Annual changes in treatment intensity (Therapeutic Intervention Scoring System 76) was assessed using linear regression adjusting for the same severity of illness model.

Cost Comparison With Previous TBI Studies

Studies looking at overall healthcare costs following ICU admission after TBI are scarce. A study from Canada estimated that the mean overall 1-year postadmission cost after TBI was $32,132 (expressed in 2007 Canadian dollars, converts to $43,791 in 2013 USD) (18). A study from New Zealand estimated that the overall first-year cost per moderate-to-severe TBI was $21,379 (expressed in 2010 USD, converts to $22,840 in 2013 USD), including both direct and indirect costs (19). A study from the United States reported total costs up to 6 months after admission to be $48,988 (expressed in USD, not specified for which year, study was conducted from 2003 to 2005, converts to $58,434 in 2013 USD) (20). Another study from the United States investigating direct hospital costs associated with TBI found an average price to be $8,189 for moderate TBI, $14,603 for serious TBI, and $33,537 for critical TBI (expressed in 1999 USD, converts to $11,451, $20,419, and $46,895 in 2013 USD, respectively) (21). A study from England and Wales found that the mean direct hospitalization costs was £15,462 (expressed in 2004 pound sterling, converts to $13,119 in 2013 USD) (22). In comparison with the previous studies, the mean total healthcare cost in the present study was $39,809 (expressed in 2013 USD), which is in line with or somewhat higher than the figures reported in previous studies.

Cost Comparison With Other Critical Care Illnesses

Like in TBI, recent studies reporting overall healthcare costs in ICU-treated patients are scarce. In patients treated for acute renal failure, the mean cost for one 6-month survivor was approximately $80,026 (expressed in 1993 USD, converts to $129,015 in 2013 USD) (23). Another study showed that the median overall 5-year cost per acute renal failure hospital survivor was €64,285 (expressed in Euros, not specified for which year, study was conducted from 2000 to 2002, converts to $71,507 in 2013 USD) (24). In critically ill cancer patients, the cost per gained life ranged from $82,845 to $189,339 (expressed in USD, not specified for which year, study was conducted from 1988 to 1990, converts to $147,661$–$337,474 in 2013 USD) (25). In patients admitted to the ICU after sudden cardiac arrest with in-hospital or out-of-hospital cardiopulmonary resuscitation, the mean cost per hospital survivor was nearly €49,952 (expressed in Euros, not specified for which year, study was conducted from 1999 to 2001, converts to $55,681 in 2013 USD) (26). In comparison with these ICU-treated illnesses, TBI treatment seems cost-effective, especially in younger patients, where the mean ECPIS for severe TBI was $104,741 (expressed in 2013 USD), which is low, considering that these patients may return to full-time employment.

Strengths and Limitations

A strength of the current study is that it was conducted in a public tax-funded healthcare and system (independent of personal insurances), which allowed accurate assessment of healthcare costs. In addition, by using the high-quality ICU database, we were able to include four of five units providing specialized intensive care for TBI patients, making our study population largely representative of the whole Finnish population. Still, there are some limitations to the study worth discussing. First, we used a novel surrogate outcome variable of poor neurologic outcome defined as those patients who had been granted permanent disability allowance or permanent disability pension by the SII. Compared with the commonly used Glasgow Outcome Scale, our definition may include a degree of inaccuracy even though it is similar to the Glasgow Outcome Scale definition of unfavorable outcome, that is, the patient is unable to live independently (27). Still, since our study was conducted in a public tax-funded healthcare system, where by law all citizens have the right to disability allowances, we believe that our definition of permanent disability adequately reflects neurologic outcome. Second, the noticed shift in practice toward treating older patients with milder injuries might affect overall sum of costs. Yet, it should not affect cost-effectiveness, as this was controlled for by performing subgroup analyses in predefined TBI severity and age groups. Finally, our study comes from one single country in Northern Europe with a tax-funded healthcare system. Thus, our results are best generalizable to countries with similar healthcare systems and one should not directly generalize our results to other countries with other types of healthcare funding.

CONCLUSION

During the last decade, healthcare costs of ICU-admitted TBI patients have remained largely the same in Finland. No change in mortality was noted, but the risk for permanent disability decreased significantly. Thus, our results suggest that cost-effectiveness of TBI care has improved during the past decade in Finland. Due to the increase need for ICU care of mild TBI and elderly TBI patients, overall TBI-related healthcare costs have increased. Yet, cost-effectiveness of TBI care appears to be justifiable when compared with patients with other forms of critical illness.

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